

# BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI WORK INTEGRATED LEARNING PROGRAMMES

**Digital**

Part A: Content Design

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| **Course Title** | Deep Learning |
| **Course No(s)** | DSECLZG524 |
| **Credit Units** | 4 |
| **Credit Model** | 1 unit = 32 hours |
| **Content Authors** | Ms. Seetha Parameswaran Dr. Sugata Ghosal |
| **Version** | 1.0 |
| **Date** | August 07th, 2019  August 30, 2020 (revised) |

## Course Objectives

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| **No** | Course Objective |
| **CO1** | Introduce students to the basic concepts and techniques of Deep Learning. |
| **CO2** | Students will be able apply deep learning models to applications. |
| **CO3** | Students will be able to evaluate deep learning algorithms. |

**Text Book(s)**

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| T1 | [Deep Learning](https://github.com/janishar/mit-deep-learning-book-pdf/blob/master/complete-book-pdf/deeplearningbook.pdf) by Ian Goodfellow, Yoshua Bengio, Aaron Courville. MIT Press 2016. |

**Reference Book(s) & other resources**

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| --- | --- |
| R1 | Deep Learning with Python by Francois Chollet. 2nd Edition, Manning Publications Co., 2020 |
| R2 | Introduction to Deep Learning by Eugene Charniak. The MIT Press 2019 |
| R3 | Dive into Deep Learning by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola. 2019 |
| R4 | Deep Learning, Amlan Chakrabarti Amit Kumar Das, Saptarsi Goswami, Pabitra Mitra, Pearson, 2021 |

**Content Structure**

1. Introduction
   1. Objective of the course
   2. Review of Machine Learning and Neural Network
2. Deep Feedforward Network
   1. Multilayer Perceptron
   2. Gradient based learning
   3. Architecture design
   4. Back propagation
3. Regularization for Deep models
   1. L2 and L1 Regularization
   2. Constrained Optimization and Under-Constrained problems
   3. Early Stopping
   4. Parameter Tying and Parameter Sharing
   5. Dropout
4. Optimization of Deep models
   1. Challenges in Neural Network Optimization
   2. Basic algorithms in optimization
   3. Parameter Initialization Strategies
   4. Algorithms with Adaptive Learning Rates
   5. Approximate Second-Order Methods
   6. Optimization Strategies
5. Convolutional Networks
   1. The Convolution Operation
   2. Pooling
   3. Structured Outputs
   4. Applications in Computer Vision
6. Recurrent Nets
   1. Recurrent Neural Networks
   2. Bidirectional RNNs
   3. Deep Recurrent Networks
   4. The Long Short-Term Memory and Other Gated RNNs
   5. Encoder-Decoder Sequence-to-Sequence Architectures
   6. Applications in Natural Language Processing
7. Autoencoders
   1. Regularized Autoencoders
   2. Representational Power, Layer Size and Depth
   3. Denoising Autoencoders
   4. Variational Autoencoders
   5. Applications of Autoencoders
8. Generative Adversarial Networks
   1. Overview
   2. Applications of GAN

## Learning Outcomes:

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| No | Learning Outcomes |
| LO1 | Able to understand the basics of Deep Learning. |
| LO2 | Able to understand and apply techniques related to Deep Learning to applications. |
| LO3 | Able to identify appropriate tools to implement the solutions to problems related to Deep Learning and implement solutions. |

**Part B: Learning Plan**

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| **Academic Term** | 2019 Semester 1 |
| **Course Title** | Deep Learning |
| **Course No** | DSECL ZG524 |
| **Lead Instructor** | Dr. Sugata Ghosal |

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| Session No. | Topic Title | Study / HW Resource Reference |
| 1 | Objective of the course, logistics, applications of neural networks, historical motivation and background, Perceptron and multilayer perceptrons, characteristics of deep learning | T1 – Ch1 |
| 2 | Deep Feedforward Networks  Deep network for Universal Boolean function representation, classification and Approximation, perceptron Learning, Perceptron with differentiable activation functions, Optimization Refresher | T1 – Ch6 |
| 3 | Deep Feedforward Networks  Gradient based learning, Cost function, output units, hidden units, Computational Graph | T1 – Ch6 |
| 4 | Regularization for Deep models  L2 and L1 Regularization, Constrained Optimization and Under- Constrained, Early Stopping, Parameter Tying and Parameter Sharing, Sparse representations, Dropout | T1 – Ch7 |

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| 5 | Optimization of Deep models  Challenges in Neural Network Optimization, Basic algorithms in optimization, Stochastic Gradient Descent, Momentum, Parameter Initialization Strategies | T1 – Ch8 |
| 6 | Optimization of Deep models (contd)  Algorithms with Adaptive Learning Rates, AdaGrad, RMSProp, Adam, Approximate Second-Order Methods, Conjugate gradient, Batch normalization | T1 – Ch8 |
| 7 | Convolutional Networks  The Convolution Operation, Pooling, Structured Outputs, Variants of convolution | T1 – Ch9 R1 – Ch5 |
| 8 | Review of Session 1 to 7 | Books, Slides, Web references |
| 9 | Convolutional Networks (contd)  Variants of CNN – ImageNet, Alexnet, VGG16, Inception, ResNet, Applications in Computer Vision | Web references T1 – Ch9  T1 – Ch12 R1 – Ch5 |
| 10 | Recurrent Nets  Sequence Processing, Unfolding Computational Graphs, Training recurrent networks, Bidirectional RNNs, Deep Recurrent Networks | T1 – Ch10 T1 – Ch12 R1 – Ch6 |
| 11 | Recurrent Nets (contd)  The Long Short-Term Memory (LSTM), Optimization for Long- Term Dependencies, Encoder-Decoder Sequence-to-Sequence processing | T1 – Ch10 R2 – Ch6 |
| 12 | Recurrent Nets (contd)  Applications in Natural Language Processing | T1 – Ch10 R2 – Ch6 |
| 13 | Autoencoders  PCA, Regularized Autoencoders, Sparse encoders, Representational Power, Layer Size and Depth, Denoising Autoencoders | T1 – Ch14 R2 – Ch8 |
| 14 | Autoencoders (contd)  Variational Autoencoders, Applications of Autoencoders | T1 – Ch14 R2 – Ch8 |
| 15 | Generative Adversarial Network (GAN) Overview, Architecture, Training, Best Practices | T1- Ch20 |

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|  |  | R2 – Ch8 |
| 16 | Review of session 9 to 15 | Books, Slides, Web references |

**Detailed Plan for Lab work**

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| **Lab No.** | **Lab Objective** | **Lab Sheet Access URL** | **Session Reference** |
| 1 | Introduction to Tensorflow and Keras |  | 2, 3 |
| 2 | Deep Neural Network with Back- propagation and optimization |  | 4,5 |
| 3 | CNN |  | 7,9 |
| 4 | RNN |  | 10 |
| 5 | LSTM |  | 11 |
| 6 | Autoencoders, GAN |  | 14,15 |

**Evaluation Scheme**:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

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| --- | --- | --- | --- | --- | --- |
| No | Name | Type | Duration | Weight | Day, Date, Session, Time |
| EC-1 | Quizzes  (Best 2 out of 3) | Online |  | 10% |  |
| EC-2 | Assignments (2) | Take Home |  | 20% |  |
| EC-3 | Mid-Semester Test | Open Book | 1.5 Hrs | 30% |  |
| EC-4 | Comprehensive Exam | Open Book | 2 Hrs | 40% |  |

## Note:

Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8 Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)

## Important links and information:

Elearn portal: [https://elearn.bits-pilani.ac.in](https://elearn.bits-pilani.ac.in/) or Canvas

Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC-1 consists of two or three Quizzes. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. EC-2 consists of either one or two Assignments. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
3. For Closed Book tests: No books or reference material of any kind will be permitted.
4. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
5. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course hand-out, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid- Semester Test and Comprehensive Exam according to the evaluation scheme provided in the hand-out.